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DDT SPRAY PROGRAMS —

THEIR VALUE AND DANGERS ..... *Ehrenfried E. Pfeiffer* 2

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DO WE REALLY KNOW WHAT WE ARE DOING? DDT SPRAY PROGRAMS — THEIR VALUE AND DANGERS

EHRENFRIED E. PFEIFFER

This entire number of Bio-Dynamics is being devoted to Dr. Pfeiffer's paper on the subject of DDT. It presents scientific evidence, pro and con, and will enable the layman to form his own unbiased judgment on an important question that affects us all, consumers as well as food producers. It will be recalled that DDT is only one of a great number of chlorinated hydrocarbons currently used in agriculture. It was chosen for discussion because it is the best known example of these insecticides.

THE EDITORS

A paper published by the U. S. Dept. of Agriculture states: "The Public Health Service points further to the success achieved in using 10% DDT powder directly on thousands of refugees and other persons abroad during and after World War II to control the body lice that carry typhus."(1) Sec. of Agriculture Charles F. Brannan, in the Yearbook of Agriculture, 1952, says: "We must stop the destruction of our crops and forests, but the insecticides we use must leave no dangerous residues on foods, destroy no beneficial wildlife and do no damage to our soils. We thought we had some of the problems solved when we got such good results from the new insecticides. *DDT, for example, made medical history in 1943 and 1944 when an outbreak of typhus in Naples was controlled in a few weeks by its use. Entomologists hoped then that DDT could end all insect borne diseases and even eradicate the housefly. In less than a decade, however, DDT was found to be a failure against the body louse in Korea and the spectre of typhus hung over that area. DDT and the insecticide substitutes for it failed to control mosquitoes in some places. In 1952 the housefly was no longer controlled in many places by any of the residual type insecticides in use and it seemed likely that other pests (those of agricultural as well as medical importance) in time would develop resistance. The answer, like the challenge, is clear. We dare not think of any knowledge — least of all knowledge of living things — as static, fixed or finished." (1a).

In "Science" it is stated that "routine application of 10% DDT powder to a large group of military personnel only in-

* DDT is the abbreviated name for dichlorodiphenyltrichlorethan or 1,1,-trichloro-2,2-bis (p-chlorophenyl) ethane, also known as chlorophenothane.

creased infestation with Pediculus humanus corporis". Resistant strains had apparently developed. (2)

Is it not rather euphemistic, in view of these facts, to state, as the USDA paper does ".....points further to the success achieved in using 10% DDT.....to control the body lice"? It is true, again, that for a short period of time DDT has been helpful, but the insect world has soon built up resistance and immunity and the only *success* in a large scale program, of which one can truly speak, is exactly that immunities of insects have been built up.

How long such immunities can last we learn from the New Zealand Journal of Sci. Technology: "A line of houseflies known to be resistant to DDT and bred in the laboratory unexposed to further DDT still showed high resistance to it after 19 generations." (3) Would it not be much safer and more honest to say that DDT is a double-edged sword and that its value is not at all established beyond doubt?

In "Conservation News" we read: The Dept. of Interior has given its blessing to a bill introduced by Congressman Lee Metcalf of Montana that would require a comprehensive federal study of what the use of billions of pounds of chemical pesticides is doing to the nation's wildlife resources. Asst. Sec. of Interior Ross L. Leffler has advised Congress the Department hopes Mr. Metcalf's proposal, H. R. 783, will be enacted. In commenting upon the bill, Mr. Leffler stated that, while he was certain the general powers of the Department provided authority to pursue such investigations, "passage of the bill would express the interest of the Congress in this particular program which we consider to be vital to the conservation of the nation's fish and wildlife resources." The Secretary also stated that the 1958 budget contains a request for funds to carry out this work. It was pointed out that last year 65 million acres of cropland — 1/6 of the nation's farm land devoted to crops — and more than 3 million acres of forests were treated with 3 billion lbs. of pesticides. "The importance of our forests and agricultural crops is unquestioned," the Assistant Secretary said. "Both are vitally needed. Likewise, insect and other pest control is necessary. However, pesticide programs have gone ahead without adequate information on the effects which the pesticides have on fish and wildlife resources. A multi-billion dollar recreation and commercial fishery industry of interest to more than 30 million Americans is involved." He stated that some

insecticides in concentrations "ten times the concentration which can be tolerated by wildlife" are being used with the resultant death of thousands of birds. He also gave examples of huge fish losses following extensive spraying of forest trees. (4)

Apparently the dangers to wildlife are not negligible; otherwise the Metcalf bill H. R. 783 would not be necessary.

There are voices from other countries too which do not endorse spraying programs indiscriminately.

Dr. C. J. Briejer, director of the Dutch governmental Phytopathological Protection Service writes: "When DDT was discovered, the problem of fighting disease spreading insects seemed to be solved. The sobering up followed quickly. The expert Commission for Insecticides of the World Health Organization which met in Geneva April 10-17, 1956 reported that 10 insect species which transmit diseases to the human body had become resistant and 27 other species already showed signs in this direction; and this after only 15 years.....In 1943, Sweden started an intensive campaign against flies with DDT. Three years later the success was over. The same happened in Denmark, Italy, Switzerland and about 28 other countries....In 1947 the Insect Protection Institute in Springvorbi (Denmark) showed flies which moved unharmed in DDT. The housefly Musca domestica had become immune to DDT, HCH, Dieldrin, Methoxychlor, Chlordane, Toxaphene, Heptachlor, Dilan and partially to Aldrin.

"Already 25 species are known in agriculture and horticulture which show resistance phenomena. A number of aphis, the peach aphis one of them, became immune in some areas against Parathion. In U. S. A., resistance against DDT by the potato bug was observed, by the cabbage fly (Pexis rapae L.), the Enasmonia (Carpacapsa) pomonella L, which causes wormy apples.....It was a lucky decision that the World Health Council called together a number of experts to study this problem. But it is astonishing that in the circles of agriculture and horticulture it remains so quiet.....I cannot share this indifference.....The percentage of resistant (insects) will be that much more, the more intensively the fight is carried out." (5)

Dr. Briejer relates the ignorance with regard to these problems to the fact that research about insecticides is mainly in the hands of chemists or chemically oriented biologists but not in the hands of geneticists (doing long range tests). The so-called

"medium toxic doses" which indicate only that 50% of the insects got killed does not indicate anything about the survival rate which follows resistance. His advice to the user is therefore not "to spray as much as possible" but "to spray as little as you can dare." One should therefore carefuly investigate what other damage can be done. It might be wiser to suffer some damage instead of having no damage for a few years and then lose control completely.

DDT will last for a certain length of time on leaves and for rather long periods of time in soils. According to a report of the University of Illinois, 105 days are required for DDT on fruit tree foliage to decline to zero and 50 days on clover. Of the insecticides discussed in this paper, lindane required, on fruit tree foliage, 15 days, aldrin 22 days, technical aldrin 27 days, chlordane 35 days, dieldrin 45 days, toxophene 85 days. On clover, the corresponding figures were: for aldrin 15 days, for chlordane 21 days, for toxophene 40 days.

Considerable literature as to the lasting effects of DDT, the crop injury and growth retardation of specific crops, exists. It appears that fruit trees, many grains, corn and potatoes, are tolerant, while rye, tomatoes, squash and snapbeans are highly sensitive. The amount of spray, especially with repeated applications, which accumulates in the soil is considerable. The summary and conclusion of a paper (59) which presents such evidence is: "A study was made on accumulation of DDT deposits on soils from 12 apple orchards, 10 cornfields, 8 potato farms and 1 cranberry bog as a result of commercial spray and dust applications for insect control during the last 6 years..... In soils from apple orchards the DDT ranged, in pounds per acre, from 35-113 under trees and from 26-61 between trees. (Most was found in the upper 4 inches of soil.) .....The cranberry bog contained a total of 34.5 lbs. of DDT per acre.....In corn soils, the total DDT ranged from 5.8-19, or an average of 11 lbs. per acre. The lowest deposits were found in potato soils ranging from about 4-15, or an average of 7 lbs. per acre."

It is true that in these studies repeated applications during the year were made. The observation period was from 1947-1952. It is also true that large quantities were applied, f.i., anywhere from 7 lbs. per acre annually to 50 lbs. per acre; or 1-2 lbs. of a 50% wettable emulsion in 100 gallons of water, at the rate of 125 gals. per acre.

Even when relatively small quantities were used, DDT could easily be recovered in the soil and accumulated with repeated sprayings.

Of the literature, the following is relevant to our subject: Alfalfa was sprayed with DDT at 0.25 lbs. (in 5 gals. water) per acre. The hay made from this alfalfa was fed to dairy cows. Average DDT residue on the fed hay was 7-8 ppm. After the first few days of feeding, the amount of DDT in the milk was about 2.3-3.0 ppm. Butter made from this milk contained 65 ppm DDT. (60) DDT is fat soluble and accumulates in fats and oils; hence it will be found there especially. DDT residues of 0.8 and 15.0 ppm were present on roasting ears of corn from plots sprayed with 2 and 28 lbs. DDT per acre. Samples of leaves and stalks from the same plots showed DDT residues of 15.0 and 190.2 ppm of the green weight. (6)

DDT also showed deleterious effects on the root growth of peach trees. The volume of the root system was reduced; the main and secondary roots were unable to produce small fibrous rootlets. However, here quantities of 25 lbs./acre were used. The material did not lose its deleterious effects toward peach growth during approximately 18 months.

Dr. Arthur Foster (USDA) told the recent meeting of the American Assn. for the Advancement of Science here that, while the effects of insecticide residues such as arsenicals on crops have been under study 45 years, some of the new organic products are presenting new aspects of the problem. DDT, apparently the most persistent, was recovered from certain soils 7 years after application in more that 80% of the amount applied. This research was done at the Plant Industry Station at Beltsville, Md. The effect on plants was demonstrated most strikingly with beans, which are particularly sensitive to DDT. Rye also showed damages, while wheat was tolerant. DDT and related components such as rhotane, methoxychlor were most persistent. (63)

One of the most important research studies was made in Germany by the Bundesanstalt for Quality Research of Plant Products, Geisenheim, Rhengau, Director Prof. Dr. habil. W. Schuphan. There several insecticides, including DDT, were studied. It was shown that the taste of vegetables was still noticeably changed 30 and 41 days after application. The protein nitrogen of Boston lettuce was reduced from 75.0% of the total nitrogen to 64.9%. The sugar was increased from 21.59%

to 24.51%; ascorbic acid was reduced from 606 mg% to 442 mg% as against the untreated control. (45)

Important for the technique of residue tests is the fact that the lowest content of DDT and other residues was observed 3-4 weeks after the last application, while thereafter an increase up to a maximum after 14 weeks was found. The fact is important because the fluctuation of absorption has not been reported anywhere else. While apples, pears, prunes and citrus fruits 4 weeks after application contained in the inside tissue of the fruit (mind: not adhering to the peel) 0.3-0.4 ppm, after 14 weeks it contained double to triple the amount. By the way, these and other observations have led the German legislature to establish lower tolerance values than the ones in force in the U. S. More striking even are feeding tests which were carried out over a two year period and two generations of test animals. The vegetables which were used for these tests were carefully washed in order to remove all outside adhering DDT, for only the effect of the internally absorbed DDT should be investigated. During the first year, only the weight curves of the male animals were lower than the one of the control. During the second year, the weight curves of the male and female animals were lower than the controls which got untreated vegetables. The autopsies of the animals after the second year of the feeding test showed significant changes of liver and spleen. The liver showed shrinking (atrophy), different from the control by a factor of 3.2. The spleen showed an even more pronounced decrease of weight. (45) For details, we have to refer to the original report, which also contains investigations on other insecticides and plant growth substances.

It gives the American reader a peculiar impression that this kind of research in Germany was partially prompted by American publications on the contents of DDT in "practically all foods deriving from agriculture, plant and animal products, even in autopsies of fatty tissues of human beings," of which numerous sources in American literature are quoted. In view of the German and Dutch publications, as cited above, can we afford to maintain a complacent attitude, similar to that which recently has done so much harm to the reputation of our country in the political and military fields, as demonstrated by the Sputnik and intercontinental missile defeat?

Prof. W. Schuphan and his cooperators conclude: "It is necessary to establish much further-reaching quality research

on agriculture products with regard to the use of insecticides, including such long term methods as outlined. The logical conclusion of it is the urgent reconsideration of food legislation. It is an absurdity that today preparations are still used in practice, the health effects of which are not sufficiently investigated and which are not proved to be absolutely harmless."

Dr. C. J. Briejer, the director of the Dutch Phytopathological Protection Service, whom we have already quoted, goes a step further and discusses the underlying general attitude and philosophy. He considers the use of toxic insecticides as brutal force. Research for other methods of combating pests must go on with all energy. "We must learn to guide natural processes into the desired direction instead of attempting to use brutal force. Here a spiritual orientation, philosophy, is necessary, a deeper insight, the lack of which we discover in many scientists. Life is to us still an incredible miracle which we should face with reverence, even where we have to combat it. In reality, the necessity of using insecticides is a proof of our ignorance and lack of knowledge, of our inability to guide the processes of nature in such a way that the use of brutal force is not necessary. It behooves us to show humility and it is not justified that we sit on the high saddle of science.

"If we can find the right way (to combat insect pests), as has already been shown with the potato nematode, then it is irresponsible to use insecticides. *This we can do only if no other way had been found* and then *only with necessary precaution* (italics by the translator). The pressure to be used on the pest population must be as little as possible. We are dealing with basic laws of nature. Everything living tries to maintain itself against damage and oppression.....Evolution is not thinkable without the principles of damage and misery.....It is to be hoped that one acknowledges also the dangers in agriculture, horticulture and fruit culture and uses the toxic insecticides less carelessly." (5)

"Everything living tries to maintain itself against damage and oppression." This sentence contains the basic philosophy of life, of biology. "Against damage" means that a living concept would try to stimulate the natural defenses, to enforce such growth conditions which enable the growing organism to remain protected. "Against oppression" means that nature will always answer with ways and means to fight off brutal force, the toxic impact of interference by man, for instance, by build-

ing up immunities which render the continuation of toxic sprays useless.

The one that suffers is the human being and human health, because the building up of defenses is a process of generations. Insects multiply fast and fight fast against oppression. Plants, animals and humans grow more slowly and have less chance to fight off damages. Dutch entomologists therefore feel that in a hundred thousand years insects may survive, but not humans, because nature has gifted insects with a greater adaptability, or may we say "intelligence"? What is absolutely necessary in a biological concept is to abandon the concept of quick returns, quick results, and to foster life, growth, to learn from the principles of natural balance.

Have all means for natural control and restoring natural balances really been exhausted, so that we are *forced* to take recourse to quick action, everlasting poisons, the health hazards of which are but insufficiently investigated, especially the long term effects? Have as many millions of dollars been spent and as many experiments conducted and as much human intelligence consumed to study and apply, for instance, biological control and non-poisoning remedies against insect pests? Only if this were done could we say there is no other way left.

It is true that there are a few entomologists, biologists, physicians, farmers, gardeners, who would rather follow the path of natural, biological checks and balances. But are they not handicapped and frustrated by the present trend of the chemical age, of research stations and government agencies which would rather increase the ever increasing supply of toxic substances to "kill" rather than to "develop"? Has not public opinion been falsely educated to see salvation in "killing and destruction" rather than to live for the ideal of growing healthy and natural crops?

There is still time to make the right turn, but now and at once. After quoting so many negative symptoms, at least an outlook for a positive, constructive solution has to be proposed.

We have stated our point herewith. We shall now go into the details of the quest to recount the Story of DDT as one test example of the present day approach. The following report contain only an extract of a wealth of information.

Resistance

DDT resistant strains of codling moth were observed in Australia. Studies in codling moth, red banded leaf roller, plum

curculio, indicated that DDT may not control certain apple orchard pests. No single insecticide gave permanent satisfactory control of all insect pests. There was no lasting effect of DDT on these pests. (6)

DDT resistant potato flea beetles are reported. DDT against the southern cattle tick was ineffective. DDT injected at 25 mg/kg had no effect; could not be detected in skin, hair, blood samples. Injections are not recommended as an immediate practice control in the absence of information on its effect on the health of cattle and on the suitability of meat from treated animals for human consumption. (7)

A review of causes of the development of resistant races, including DDT, with 80 references. (8)

Resistance of insects to chlorinated organic insecticide. (9)

Attention gypsy moth: Several insecticides were tried, DDT being one of them. DDT was effective only after the caterpillars were hatched. (Question: Was the N. Y. State spraying program properly timed for all areas?) Rapein and mineral oil could be applied with good results at any time. (Question: Why use DDT then?) (10)

"DDT continues to enjoy an appreciable demand, although it is being replaced by malathion and other newer chemicals in fly control. The N. Y. State Agricultural Experiment Station recently announced that DDT is steadily losing its effectiveness against cabbage worms. Although this insecticide originally gave almost complete control, it is now of doubtful value in New York cabbage fields." (11)

No wonder that an Associated Press release of April 4, 1957 states that pests cause new worry. Entomologists thought they had licked the problem of destructive pests. Apparent success after success was reported. Then came the immunities, that is, "the counter-attack" by the pests. The Dept. of Agriculture in its monthly magazine, "Agriculture Research" demands a new approach, more basic research on the physiology of insects, as well as the use of trapping, spiced with attracting substances, and the developing of resistant plants. This might take ten years or more. "In all fields we need to build up more fundamental information."

"The studies of DDT-resistant flies are considered to be particularly important, for in many areas the effectiveness of DDT as a control of houseflies has decreased to the point where it is nearly worthless." Investigations are made to find out

why the flies become resistant and studies are performed on how to overcome this resistance. "As yet the researchers see no immediate practical application of the work on growth or development inhibitions." (12)

There is no doubt that DDT has been effective against many insects. Literature on it is too long to be quoted here in detail. There is also no doubt that repeated strong doses were more effective than small doses. This is not our point. Our point is that the increasing resistance to DDT of many insects would make it necessary to increase the dosage beyond the limit of permissible tolerance. These side-effects — increased resistance, spray residues even of most minute quantities which, in turn, accumulate in plants and from there are carried to the fat of animals and human bodies — make us doubt that DDT is a suitable insecticide. The price which has to be paid for these after-effects may more than compensate for temporary, short-lived success.

An enzyme, DDT-dehydrochlorinase, has been discovered in DDT resistant flies. It requires activation by glutathione, an important factor in healthy metabolism. It is effective in slight alkalinity. It requires a large surface to attack and performs better on nitrogen in vitro. Inhibitors seem to exist. Some strains have more, others less or nothing of this enzyme. (72) (Question: Many unknown factors of the specific biochemistry of an organism are involved; one is: How does an acid-alkaline imbalance in the food with excess of acid formation influence the protective enzyme mechanism?)

Residual Effects:

The continuous use of.....DDT for pest control purposes presents the hazard of residue build-up in the soil which may be toxic to plants. (15)

Quantitative recovery of DDT from Uganda mud blocks after 12 months was complete. (16)

Food products derived from plants treated with DDT contain residual DDT. In view of the cumulative effects of DDT, the need for permissible residue standards is stressed. (22)

Corn stover was treated with 1.5 lbs. technical DDT in 10 gals. of water per acre in two applications, one week apart. The plants contained 23.3 ppm DDT. Biopsy samples were taken every month for four months. The animals were removed after two months to untreated fields. The fat of steers contained 1.0-2.8 ppm DDT at the end of the first and 5 ppm DDT at the

end of the second month. After 5 months. a residue of 0.1 ppm was still found. (14)

Flour made from cereal grain treated with DDT and examined six months later contained up to 8 ppm DDT. After 9 months of storage, still detectable amounts were present in the flour. Only in bread made from this flour was there no DDT discovered. (19)

Residue:

Strained processed peaches and pears containing known quantities of the active ingredients ranged in concentration from 0.25 to 10 ppm. (64)

In order to make it "easier" for the farmer, the incorporation of insecticides in fertilizers is now tried and recommended in application rates per acre of 1-25 lbs. of DDT for the control of army worms (in pastures; this in spite of the fact that DDT has been found in grasses, alfalfa and milk and is considered to be a contaminant in milk) against European chafer, insects of lawns, turf and ornamental plants, sweet clover weevil, white-fringed beetle, wireworms. Suggested crops are: lawns, non-cultivated crops (wildlife feed!), ornamentals, pastures, potatoes, sweet clover, turf and unspecified crops. (65)

The following fertilizers, chiefly in the south Atlantic states, containing 1.5-40 lbs./ton of fertilizer are in use: 0-10-20, 0-14-14, 3-9-9, 4-8-6, 4-8-8, 4-10-7, 4-12-12, 6-8-4, 6-8-6, 6-20-20, according to this source.

Since farmers sometimes mix their own fertilizers, there seems to be a free field for all. "Many states," the paper says, "analyze the mixtures for their pesticide content, but very few have established tolerances for deficiencies or excess of pesticides." Fortunately, the report also states that many problems in the agronomic, entomological and regulatory control are involved, "many of which have been solved only partially or not at all."

The addition of insecticides to fertilizers (which the fertilizer industry prefers not to do but the farmers are insistent) has increased 70% from 1953-54. Some 149,100 tons were used in 1954 — 42,600 tons in the west north central region, 73,200 tons in the south Atlantic, with South Carolina as the biggest single state (30,000 tons). Aldrin was first, chlordane second and DDT apparently third, heptachlor moving close to aldrin in 1954.

Biological Balance:

Studies with about 4 lbs. DDT/acre as 2% water emulsion spray revealed that a single application may do more damage than good by reducing natural predators of mosquito larvae. All mosquito larvae and invertebrate predators in the test plot were killed. The predator population recovered, together with the mosquitoes, but to a lesser extent. (28)

Insecticides such as parathion and toxaphene-DDT combinations were found to be highly toxic; toxaphene, endrin and DDT singly were moderately toxic to beneficial insects in California cotton and alfalfa fields. (29)

A 1% mineral oil emulsion containing a 0.2% aqueous suspension of 5.0% DDT dust produced side-effects by increasing the amount of tree mites and decreasing the sugar content of the fruit. It was stated that mineral oil emulsion was most harmful because of its better penetration into the leaf epidermis at the spots injured by mites. The sugar content of the fruit of three different varieties decreased from 14.2 to 11.0, 15.1 to 12.2 and 19.25 to 15.02%.

DDT was sprayed against tent caterpillar, gypsy moth and potato beetle but it also killed the natural enemies. It did not succeed against wooly aphis but killed Alphelinus mali, the natural enemy of it, so that it helped to spread out the wooly aphis in orchards. (46)

"DDT is remarkably effective in controlling codling moth, but it also kills parasites and predators that have held other pests in check. In some areas where DDT has been used to control codling moths, mites have become almost as serious as codling moth originally was." (47)

The major problem in the use of DDT has been the build-up of mites, aphids, sooty molds and scales following spraying. (48)

That pests have gotten the upper hand in modern agriculture is only the result of the violation of natural laws and balances. It is here that the first steps of improvement have to be made, not with spraying programs.

The biological balance between parasite and predators could be disturbed in many ways: (a) the parasite building up a resistance and the predator not; (b) the predator dying of starvation because the parasite is "successfully" reduced. On California citrus trees, ants were destroyed with chlordane (and DDT) applied to the soil and trees were sprayed against red

scale. "On the trees where parasite activity had been suppressed, more than 100 times as many scales were found than on the ant-free, untreated trees." "Even when a poison has no direct effect upon a predator, it may lead to the death of the greater part of these useful insects," says Alan Goldman.

Honey bees exposed to DDT run about without sense of direction, sting each other. Lack of light, cold, starvation, increased the effect of toxic dust. The effect of poisonous pollen continues long after spraying, on young bees and larvae in the hive. (75)

Red Spider frequently got the upper hand because of the destruction of natural enemies. On the other hand, bees were wiped out completely after a spray program in Jefferson and St. Lawrence County, N. Y. and beekeepers sued the state for $200,000 damages (N. Y. Herald-Tribune, Aug. 23, 1953). (66)

DDT and Plants:

Studies of vegetables beginning 15 days after the last spraying showed changes in the nitrogen metabolism of these vegetables, for instance, cabbage. The protein nitrogen was decreased but the nitrate nitrogen was increased. (Nitrate in plant tissue is not considered to be a favorable health factor in diet.) (49)

6-10 weeks after spraying, effects of DDT could still be discovered in vegetables and fruit with a special "fly test." (50)

Emergence of soya beans was reduced and seed size was somewhat decreased in 1950 tests. No other effects were observed in 1950 but in 1951 all treated plots (also with BHC, chlordane and parathion) showed a higher oil content than the untreated. (51) This observation is interesting because a shift which causes increase of oil also causes decrease of protein, that is, a major change in the metabolism of the plant.

High concentrations stunted and deformed plants, caused chlorosis and necrosis. The order of susceptibility was (from high to low): squash, cucumber, tomato, bean, carrot, potato, pea, corn. In very high dilutions, no injuries were caused; even growth stimulation was observed. It seemed that growth into length (height) was stimulated. Beans, corn and cucumber seed planted in treated sawdust showed delayed germination; later the growth became more rapid than that of the control. The degree of dilution was specific for each species. Squash and cucumber reacted to 0.0005% DDT; carrots and potatoes to 0.5-2%. (52)

This writer becomes a little suspicious when he reads of growth stimulation. That a plant grows faster or taller is not always a sign of improved nutritious quality, as studies on the amino acid patterns of protein have shown. (69)

Off flavors have been observed. (45) One farmer lost a whole crop of melons because of it. (66) Significant reduction in the number of runners on strawberries was observed, as well as the green and dry weight of plants when technical DDT concentrations reached 12 lbs./acre. Technical DDT caused more suppression of growth than 1 ppm DDT. (53) Reports of crop damage have frequently appeared in newspapers. John J. O'Neill published complaints of Long Island farmers because of reduced yield in fruit orchards due to reduced pollination of blossoms: the pollinating bees and other insects were killed. The growth of Elberta peach tree seedlings was disturbed, the volume of the root system was reduced, the main and secondary roots were unable to produce small fibrous rootlets. The material did not lose its deleterious characteristics toward peach tree growth during approximately 18 months. It is true that in these experiments unusually high amounts per acre were used, so that the author reports "as little as 25 lbs./acre" caused damage. (54) But then we should realize that many a farmer, not familiar with proper dosages, uses excessive amounts "in order to make the spray work."

Impure forms of DDT show longer residual effects than pure forms. (55) Excessive residues are to be avoided. Therefore, sprays should not be used too close to harvest. DDD, TDE, DDT should not be used closer to harvest than 30 days. (56) (Question: How about sprays used in May which hit green vegetables, radishes, strawberries, spinach, lettuce? No tolerance time is left there; even when they only drift in from neighboring orchards or forest areas.)

Prof. W. Schuphan concludes that there is an ever increasing danger of soil contamination by chlorinated hydrocarbons. There is also the danger of taste, flavor and biological value decrease and chronic long range damage which does not become apparent at once. Conclusions with regard to human welfare can be drawn. Growth and yield reductions are reported. The question is raised: How much of the insecticides used for seed treatment will go into the plant or remain in the soil? He recommends: One has to appeal time and again to the feeling of responsibility of the practical grower to use protective means

and synthetic growth substances only in the utmost emergency, when *all* other means have failed, such as optimal location, vigorous and healthy seed, disease and pest resistant varieties, proper crop rotation, proper soil cultivation, harmonious (balanced) soil and plant nutrition, biological control. Finally, he demands that insecticides be tested and admitted only after a certificate of absolute harmlessness with regard to acute and chronic damage is issued. (56)

DDT-Bordeaux sprays in 6 year experiments reduced the growth by 20% and yield by 10% in Concord grape vines. (20)

DDT emulsion sprays deposited greater residues on corn leaves than DDT granules. (25)

Here it must be added that the European corn borer can be very well controlled with Rhyania, a harmless insecticide, apparently not building up resistance, and DDT would not be needed.

Rhyania compared favorably with DDT in the control of codling moth, leafhoppers, apple mealy bugs, tent caterpillars, apple maggots and apple aphids. Best control of codling moth in Nova Scotia was obtained with 3 applications, beginning when the first eggs hatched and repeated every 7-10 days. (30)

Various mixtures of insecticides, including DDT, were tested with regard to the changes of plant taste. This was adversely affected, even though the residue at 5-12 days after application was below tolerance.

Effects of chlorinated hydrocarbon insecticides on the flavor of vegetables are reported in a dissertation by John James Birdsall. (27)

"It is not uncommon to come across plants which have been damaged by insecticides, but too few of these cases appear in literature." It was stated that frequently plant physiologists were unaware of the vast amount of spray damage that occurred annually. Subtle changes in growth pattern, maturation, early arrest of vegetative growth have been observed. Even though seed germination of tobacco in Southern Rhodesia was not affected, subsequent seedling growth was delayed (using BHC). Inhibition of plant growth hormones was seen. DDT damage on cucurbites is well known (74), especially when the foliage was damp or wet.

On the opposite page of this report, we read that DDT, as reported by the Connecticut Agricultural Experiment Station in 1946, successfully controlled Japanese beetle at the rate of 25

lbs. DDT/acre and that the insecticide persisted for several generations. (74)

Damage:

Feeding of diets containing 0.02% DDT to breeding quail did not influence the adult birds but reduced the hatchability of eggs and viability of chicks. Chicks showed high mortality, even when reared on a DDT-free diet.

"Feeding tests on quail and pheasants, by the way, showed that other chlorinated hydrocarbons such as aldrin, dieldrin and endrin were at least 100 times more toxic to quail chicks and at least 20 times more toxic to pheasant chicks than is DDT." "Mortality rates among pheasants fed 50 ppm and quail fed 100 ppm DDT were significantly higher than those in the control group." No demonstrable effect upon egg production, percentage fertility or percentage hatchability were produced by the inclusion of 200 ppm of DDT, but the viability of chicks from these birds was markedly reduced in the DDT groups, where 87% of the chicks died within the first 6 weeks. While no apparent effect throughout the growth, maintenance and reproduction period of the parent generation was observed, that is, a normal number of eggs was produced, the fertility was 25% lower than that of controls. Chicks from these matings failed to survive even when fed insecticide-free diets. (13a)

Toxicity tests of DDT for four species of birds and three of mammals conducted at the Patuxent Research Refuge indicate considerable variation in the toxicity action of DDT. The carrier of DDT seems to play an important role, showing greatest toxicity in vegetable oil (about 5 times as much) when crystalline DDT was used. 50% mortality on bobwhite quail was observed at levels of 0.025% and losses still occurred at 0.005%. Typical symptoms of DDT poisoning were seen (excessive nervousness, anorexia and tremors prior to death). Adult wild mallard and pintail ducks evidenced toxicity to DDT for all levels above 0.025%. Toxic reactions were seen at 0.1% but no fatalities occurred. Starlings showed demonstrable histological damage to the liver at 0.06%, but on the 28th day 5 of 9 birds were released as normal. At the 0.2% DDT level in the diet of the cottontail rabbit, evidence of toxicity was seen in only one of five, but at the 0.4% level 3 out of 4 rabbits died by the 21st day. Multiple areas of focal necrosis of liver and kidney were seen upon autopsy. Chronic toxicity appeared in meadow mice at the 0.2% level of DDT. All animals fed below

0.2% of the diet survived the 31 day test period. In white footed mice, characteristic lesions of tissues were seen in the surviving animals at the 1500 mg/kg level. Chronic toxicity resulted in clinical symptoms only if the diet contained more than 0.1% DDT. (13b)

117 acres of dense woodland on the Patuxent Research Refuge received an aerial application of DDT in oil at the rate of 2 lbs./acre annually for 5 years. (The DDT reached the ground level in much smaller amounts, being absorbed by foliage, estimated at one hundredth to one thousandth of a pound.) No significant damage to wood mouse and box turtle was seen. (13c)

In the foreword to a summary of investigations of effects of DDT and other insecticides during 1947, the director of the U. S. Dept. of Interior, Fish and Wildlife Service, Albert M. Day, says: "The Fish and Wildlife Service is gravely concerned over the effects on beneficial fish of such widespread use of toxic agents....." The summary reports that in one area of more than 400,000 acres of forest land in Idaho, DDT was applied by airplane at the rate of 1 lb./acre in oil for the control of the Douglas fir tussock moth. "Birds and mammals were unaffected. Fish were affected but slightly in the area as a whole, but rather heavy losses of some species were noted in limited regions." In the Teton National Forests, 5 to 7½ lbs./acre caused heavy bird damage and indications of damage to mammals also were seen. Fish showed less damage than in other areas, probably because beaver dams restricted the flow of water. In the Black Hills, no measurable effect on birds and mammals was observed but the area sprayed was small and the birds were already over the nesting period, that is, not restricted to the area. (13d)

(During the 1957 spraying in Rockland County, New York, it was observed that birds left the sprayed area but came back later on.)

Indications of heavy song bird mortality were seen in a Maryland orchard district with seasonal totals of 50 lbs. DDT/acre.

In an experimental program of tick control in Texas, DDT dust was used at 4.36 lbs./acre and caused a reduction of 50% in the bird population. In a Maryland woodland, aerial treatment of scrub and sapling growth with 5 lbs. of DDT/acre caused heavy bird mortality. Three of the commonest species were reduced 80%; the total reduction for the 5 commonest species was 65%.

Aerial application of DDT in oil at the rate of 1 lb./acre to a one mile section of Back Creek, W. Va. caused a nominal kill of fish but a heavy kill of bottom fauna. At the lower end of the one mile section, more than 90% of the aquatic organisms were killed. Studies on oysters showed that these were fairly resistant.

The Wildlife Service suggests using DDT only after weighing the value of such control against the harm that will be done to beneficial forms of life; to use it only where it is needed and in all cases to use the minimum quantity necessary for control of a pest. Wherever it is applied by airplane, provide careful plane to ground control to insure even coverage and to prevent overlapping local dosage. Because of the sensitivity of fish and crabs to DDT, avoid, as far as possible, direct application to streams, lakes and coastal bays. In aerial applications over aquatic areas, use 1/5 lb. or less of DDT in oil to an acre..... If treatment is repeated several times in a season, use 1/10 lb./acre or less.....for ground methods of application these dosages should be reduced by 50%.....In forest areas, use less than 2 lbs./acre to avoid damage to birds, amphibians and mammals. Because of its great toxicity to many aquatic forms, use smaller quantities of DDT in emulsions. Spraying during the nestling period of birds should be avoided entirely.

(It became evident that during the 1957 New York State gypsy moth program, plane-ground control was insufficient, the "on contract" spraying planes did not observe the rules, and the spraying was done during the nesting period of birds.)

Other papers containing similar information and recommendations are mentioned in the bibliography. In fact, a wealth of reports exists, but it is not possible to give all the details in a short paper, but we feel that a few more points need attention.

One interesting factor, for instance, is the fact that in free choice tests with birds, they would use the unadulterated feed 10-11 times more abundantly than that treated with chlordane or toxaphene, but in the case of DDT addition, they could not discover it. (13f) This fact in itself involves the danger that birds cannot protect themselves by avoiding DDT contaminated feed. While a one year spray program (13g) did not show significant damage at the Patuxent Research Refuge, a four year application in succession (2 lbs. DDT in oil) per acre on bottomland forest resulted in the breeding population under-

going a 26% decrease by the fifth spring. The American redstart was reduced by 44% with marked reaction immediately following each application, the parula warbler reduced 40% and the red-eyed vireo reduced by 28%. (13h)

1 lb. DDT/acre on spruce budworms in the Adirondacks did not sufficiently exterminate the insects, so that nestling birds were fed contaminated and uncontaminated material. No damage to the nestling was observed. In laboratory tests, however, it was found that underfed nestlings on a starvation diet became susceptible to DDT poisoning, showing the typical symptoms. For two days the birds got all they wanted, the third day starvation diet, then returned to their natural environment: 20% died, 22.7% additional showed DDT poisoning symptoms. Some species (flycatchers and waxwings) were less susceptible than others (vireos, warblers and sparrows). (13f)

The importance of this report lies in the fact that it points out that starvation causes an increased susceptibility. Starvation might very well occur when the spraying program against the insects was successful.

In another report (13k) damage to fish (some species more than others) is mentioned. Drifts or direct application to impounded water should be avoided under normal agricultural uses. DDT and BHC seemed to be less toxic, though, than other insecticides such as chlordane, toxaphene and parathion. Toxaphene showed damage to young birds but not to adult animals.

At the test level of 0.1, 0.2, 0.3 lbs./acre in oil by airplane with BHC, DDT and strobane respectively, some insignificant damage to fish in ponds, but less in streams, was observed. The marsh fiddler crab showed 68%-80% mortality in cages against 16% of the control. (13L)

A report on a spray program against the bark beetle causing the transfer of the fungus of Dutch Elm disease in Princeton, N. J. mentions that a vast majority of birds died from DDT poisoning. Significant was the fact that migratory spring birds, whose body fat which ordinarily stores large amounts of DDT, is low at the migration period, were very susceptible to acute poisoning. Spraying during migration time, therefore, is particularly damaging, especially to birds which feed in the crown canopy of trees. Robins and myrtle warblers seemed particularly subject to loss. After migration, losses were less. (13m)

The reverse problem of migration, to the knowledge of this writer, has not been named, namely, that birds store large

amounts of fat before migration in Fall, on which they live during the flight to warmer locations. Since fat stores DDT, this must be released in quantity during flight. The paper (13m) suggests covering ponds and bird baths. Until better methods of control are found, the writer of that paper believes that DDT must be permitted against Dutch Elm disease. Contaminated puddles on streets should be removed and gutters flushed. A 22% decline of bird species common to both sprayed and unsprayed areas, as against a 6% increase in numbers of these same species in the unsprayed area was observed. The young seemed to be especially susceptible; therefore, one should not spray during nestling time. In this report (13n), however, it was also stated that the area 3 weeks after spraying had returned to normal level.

Spray programs in Switzerland caused considerable damage to wildlife. The population of some "Kantons" (states) of Switzerland has therefore already voted against the continuance of these programs. (from a letter by Paul Keller 10/21/57; cf also 32)

A section of the Blue Nile was sprayed with DDT in oil with a surface active agent, calculated DDT content 0.09 ppm. When the water reached the observation site, the DDT had been diluted about 4 times. Many fish died. Examination revealed DDT poisoning as cause of death. The survival of the fish showed a direct relation to the fat content of the tissues. (24)

One of the most complete reports on pesticides, with about 1,000 references and a thorough case history of all aspects of the DDT problem, has been issued by the State of California, Dept. of Fish and Game. Everyone who is interested in the problem of insecticide uses and dangers should read this brochure very carefully. (57) If he continues to use pesticides, he at least knows what he is doing.

"Insecticides must be used with caution if damage to wildlife is to be minimized," says an article by J. P. Linduska. (67) He feels, however, that 1 lb./acre of DDT might be tolerable, while 4-5 lbs./acre always presents critical conditions for birds. "While this quality of DDT (stability transfer from pasture to milk) may be desirable from the narrow standpoint of its value as a killer of pests, it presents compensating disadvantages where a chronic toxicity hazard is concerned. And this, in fact, has led to its disqualification as material for use around dairy cows and livestock." Linduska feels more concern about super

bug killers which are now invading the central field. "The new super bug killers are of such a potency that any margin of safety will be a narrow one indeed. And future mistakes are likely to be far more costly....." A fact-finding program has to be introduced soon, he demands.

A comprehensive paper on the subject was written by Paul F. Springer (130). We quote: "Despite the enormous good wrought by insecticides, they must be considered in the category of mixed blessings."

A summary of literature on insecticides and wildlife has been prepared by the Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, containing the listing of 51 papers on insecticides over the years from 1945-57, of which 31 mention DDT in the title. It is beyond the scope of this paper to extract all of these papers. One conclusion with regard to wildlife appears to be near: *The use of DDT, which was used as the best known example of chlorinated hydrocarbons is a double-edged sword. The use of these insecticides should be restricted to the absolute minimum and should be considered only in the greatest emergency and only after all other means have been exhausted. Mass application or routine and frequent applications, as is done frequently in modern agriculture and orchardry, has no place in restoring proper balance in nature. When used, the utmost skill and judgment is to be applied. Indiscriminate use can cause more damage than good.*

Reports from other countries substantiate this point of view. As a curiosity, we may mention the story which was published in Swiss papers during the early days of DDT. The City of Basle had a meadow outside of town heavily infested with June bugs (Maikaefer). DDT was sprayed and subsequently washed into the spring water intake area of the city by rain. When the city dwellers let their drinking water evaporate on a plate, flies feeding from it were killed. The joke was made in Basle that one does not need to buy DDT; one gets it free of charge with the drinking water. This, of course, was in the years when flies had not become immune as yet.

Contradictions:

In spite of the evidence presented which makes the use of DDT of rather doubtful effect, we still can read that it is recommended. "DDT and other chlorinated insecticides are the active ingredients of the granules tested against the corn borer. Granular formulations are showing promise in a number of other in-

sect control problems. Already they are commercial in mosquito control on coastal lowlands, turf insects on residential lawns, some pasture pests, and on corn root worm in some areas .....While granular DDT hasn't usually given statistically better control than the same insecticide in emulsion form, it has a number of advantages.....namely, easier to handle." "In the Aukeny tests, DDT emulsion applied at 1.5 lbs./acre gave a residue of about 150 ppm at harvest time. Comparable granular applications gave a residue of 15 ppm."

In this report, after the use of granules has been recommended at the rate of 5% DDT of 15-20 lbs./acre with ground equipment or 20-25 lbs./acre by airplane, a few precautions are added: "Light residues may remain on leaves, stalks and husks" but "will not produce ill-effects on livestock eating such plants. Some DDT may be excreted in milk or deposited in fat. Until more information is available, DDT contaminated plants should not be fed to dairy animals. Animals should not be fed DDT contaminated plants for at least 90 days before slaughter." (31)

We also feel obliged to report on a paper by Trean and Cleveland from which one can gather that aldrin, dieldrin and lindane in animal tests were more toxic than DDT and that smaller quantities of DDT fed to rats did not seem to cause damage, while dogs were more susceptible to aldrin and dieldrin. (68)

These findings are somewhat in contradiction with the findings of Schuphan (45), which brings up an interesting problem. By direct addition of DDT (and other insecticides) to the feed ratio, in general less toxic phenomena were observed than when the DDT, etc., were absorbed by a growing plant and entered the organism in the food.

Biologically, the organism seems to be more resistant and has better defenses against direct application as compared with indirect effect. Changes of toxicity may be due to changes in the enzyme systems of the absorbing plant and subsequently in the organism living from this plant. The problem of direct defenses and the lowering of same by indirect absorption has not been investigated sufficiently and also has to be considered. The biologist still has a task ahead of him.

That other mostly yet unidentified metabolites build up in the digesting or absorbing organism can be concluded from the fact of the building up of resistance (due to enzymatic changes).

The dehydrochlorination process in the housefly has been investigated. "The interesting but complex phenomena of production of other metabolites remain, essentially, academic in nature." (70)

Looking Over the Health Problem:

The peculiarities of DDT which lend themselves very well to a logical examination and therefore occasionally might deceive an experimenter so that wrong conclusions with regard to the harmlessness of DDT are drawn appear in a paper on quail and pheasant studies. Toxic symptoms show up at different speeds after ingestion, minute quantities taking a longer time. Young birds (not nestlings) appeared to be more resistant than adults; in fact, young birds could take more than twice the median lethal quantity for adults without showing ill effects. "Chemical analysis of tissues showed that quantities of DDT stored were not proportional to the total amounts administered, nor to the duration of exposure, but were related to the severity of toxic symptoms. Concentration of the toxicant in breast muscle of birds dying of acute DDT poisoning was approximately 34 microgram/gram in adult quail and 22 microgram/-gram in adult pheasants." (33)

"It is conceivable that nestlings inadequately fed or for other reasons low in vitality could succumb to small quantities of DDT, whereas healthier individuals nourished normally by their parents might survive for a longer period even though they consumed more DDT." (34) There is no correlation between the quantity of DDT found in tissues and the quantity ingested.

This brings up an important problem, namely, the general state of health of the affected organism. *What is poison to one might not be toxic to another, or vice versa, depending on the susceptibility of the individual organism. Malnutrition, liver, kidney, metabolic disease, allergy, might have a great influence on susceptibility.* Whether a body stores away DDT in fat or releases it from the fat, for instance. when consuming the storage fat or reducing, plays an important role. That no ill effects showed up immediately during the feeding test is no proof that later on toxic or even fatal occurrences might not take place when changes in the health and metabolism of the organism occur. This problem has so far not been sufficiently investigated but is an important item if residue or lasting effects were studied.

Some aspects, for instance, the toxicology proper, have been dealt with properly in the classic by Dr. Arnold Lehman (77) and are not reported here. Also, the important papers by Dr. Biskind could not be entered here. (78)

Health Problems:

The U. S. Dept. of Health, Education and Welfare issued a brochure, "Operational Memoranda on Economic Poisons" revised April 1, 1956 which contains the official information on many insecticides, including chlorinated hydrocarbons and especially DDT. We learn that it is easily decomposed to a nontoxic material under alkaline conditions, especially if iron is present. This fact might explain why the writer's own experiments with DDT on composts and manures, all of which turned alkaline, did not seem to interfere with the compost fermentation and earthworm action. Of course, the earthworms which got hit directly were killed, but others in the compost pile survived and multiplied. Elsewhere it was reported that earthworms would not take freshly sprayed leaves but attacked without apparent harm two months afterwards or later. It also explains that DDT in acid soils and especially acid forest soils may last indefinitely. The above brochure mentions the apparent harmlessness to humans "particularly from the standpoint of acute toxicity." In this careful wording, which is based upon many tests, lies the crux of the problem. The acute toxicity, indeed, might be harmless, but the chronic toxicity of the most minute quantities, especially if it accumulates in the fat of plants, animals or human beings, if it is enhanced by synergistic reactions and even more by conditions of an entirely different nature not under the control of any spraying program, such as disease, liver, kidney disorder, susceptibility of the receiving organism (man) due to his own specific physiological condition (f.i. allergy), creates the problem with which we are concerned. The behaviour of birds has already demonstrated that the degree of toxicity is not entirely, if at all, dependent upon dosage but upon the condition of the recipient. The Dept. of Health, etc., therefore states very correctly that "reasonable precautions should be taken to avoid breathing dust, mist or powders and to avoid direct skin contact with the chemical in any form." (This is what upset people in Rockland County and Long Island — that during the gypsy moth spray program of 1957 children waiting for the school bus got sprayed because the low flying plane was

"late," and in Long Island the DDT in the air lasted in measurable amounts for a long time.)

Spraying at the rate of only 1 lb./acre suspends in an air space 30 ft. high above the ground 0.0112 gr. per cubic meter. The human being, in a resting state, inhales about 5 liter of air per minute or 7 cubic meter/day. In active motion, twice that much. 0.08-0.16 gr. are inhaled that day. One public agency fights against air pollution; another supports it in fact.

"Contaminated skin areas should be washed with soap and water and excessively contaminated clothing should not be worn."

"The Food and Drug Administration has ruled that DDT in milk is considered a contaminant; therefore DDT should not be used on dairy animals or in dairy barns."

We add: It should also not be sprayed in areas where it has a chance to get into the milk or fat because of its adherence to pasture feeding, animal hay or grain, or because it was used for the spraying of trucks, railroad cars, ship holds or containers in which feeding or food for human consumption is to be shipped. One should not forget that even the most minute quantities will accumulate in the body fat. The brochure (34) states, however, that "domestic consumption totaled approximately 240 million lbs. during crop years 1951-1954, and in the crop year 1954 alone more than 42 million lbs. were exported. No detrimental effects to users have been evident." We feel obliged to reduce this statement with the remark: no gross toxic effects. The systemic damage under adverse conditions of the individual is an entirely different problem which would need careful study.

The brochure mentions the necessary precautions with regard to aquatic life and that treatment with a rather diluted spray was "totally destructive to fish and most other aquatic organisms present in the water.....should be restricted to such places as temporary pond areas where there is no hazard to fish and other aquatic life." Some other communications in the brochure with regard to house and body pests, in view of other reports (2) as to the building up of resistance, might be a bit optimistic.

Pyrethrum preparations, also dealt with in the paper (34), could very well be substituted for DDT, inasmuch as no resistance is known so far, especially for the purposes of the hygienists. From all we can understand, there is no need for the problem to be solved with DDT and related compounds.

We now arrive at the problem which is probably the most difficult to understand and appreciate: How much evidence is there really that DDT is harmful to the human being? It has been demonstrated that chlorinated hydrocarbons (of which DDT is one) cause toxic reactions in various animals in various degrees. "In experimental animals killed by large doses of chlorinated hydrocarbon insecticides, dilation of blood vessels and even small petechial hemorrhages secondary to convulsions may be encountered. The outstanding changes following repeated DDT feeding in rodents are found in the liver. These changes consist of centrolobular hypertrophy, margination of cytoplasmic granules, fatty infiltrations and lipospheres. Similar changes occur in combination following exposure to other chlorinated hydrocarbon insecticides and occur separately in a wide variety of toxicants. These changes have not been found in the higher animal or in man. All animals show liver cell necrosis but only at very high levels of dosage." (36 p. 25)

"Nervous symptoms and convulsions entirely similar to those of chlorinated hydrocarbon insecticide poisoning may be induced by a variety of economic poisons as well as by even less specific neurological disease. If maximal symptoms are not reached within a matter of a few hours after acute exposure, then another diagnosis or some complicating factor should be sought." (36 p. 25-26)

If we analyze the physiological reaction of the people, then we must consider another viewpoint. The compounds under consideration, especially DDT, have one property in common: they are stored in body fat. "Such storage results either from a single large dose or from repeated small doses. The materials stored in the fat appear to be largely inactive since the total amount stored in an experimental animal often may be greater than the lethal dose if given at one time." (36 p. 25)

For the fat storage capacity, however, simply amazing figures are given: of 51 human volunteers, 18 ate 35 mg per man per day, four as long as 18 months, without producing any adverse effects. This dosage of 0.5 mg/kg body weight/day is about 200 times the daily rate at which the average citizen in the U. S. receives DDT in his diet. These volunteers stored from 101-466 ppm of DDT after 12 months. "The actual concentration in prepared meals is in the order of 0.25 ppm (dry basis) and the consequent dosage is calculated to be 0.0026 mg/kg/day. (36 p. 35)

"This dietary DDT is undoubtedly the major source of DDT and DDE stored in the fat of persons in the general population. A study of 222 persons, some with moderate occupational exposure, showed that they had stored as high as 61 ppm of DDT and as high as 95 ppm of DDE with a mean of 9 ppm of DDT and 12 ppm of DDE." (36 p. 35)

Hogs fed with a daily dose of 1-3 gram Anoxid (a mixture of DDT, BHC, 1 gram to 1000 gram of grain) produced toxic symptoms and accumulation of DDT in the meat. The meat became unsuitable for human consumption. (17)

Acute dermal and oral toxicity to livestock is reported. (18)

"The dangers of cancer formation resulting from the presence of pesticide residues" is discussed by Rene Truhaut. (21)

In medical reports one reads that no fatal case of DDT poisoning was seen. One, at least, is reported in Lancet 251, p. 235-6, 1946, after ingestion of 34 gr. DDT. Necropsy showed pulmonary and gastro-intestinal congestion. (76)

The Illinois Public Health Dept. has recently established a special blood testing service "to detect possible poisoning from exposure to insecticides. Dr. Roland R. Cross, the department's director, states that greater use of insecticides has increased exposure to poisoning.

Another report (37) published in the J.A.M.A. 1956 estimated the dietary DDT residue from agricultural products as averaging 0.184 mg/man/day based on the analyses of whole meals. 69.6 ppm of DDT were found in one breakfast of stewed fruit. A certain bread baked with lard with a relatively high concentration of DDT showed a concentration of 100.9 ppm of DDT. Except for 3 volunteers, all others in this study made in a federal correctional institution were normal. The storage in fat ranked between 3 ppm (minimum at zero day) and about 466 ppm (maximum). An unexplainable difference between technical and recrystallized DDT was found. (For further details, the original paper should be consulted.) The summary of the paper states that "during the entire study, no volunteers complained of any symptoms or showed, by the tests used, any sign of illness that did not have an easily recognized cause clearly unrelated to exposure to DDT."

One weakness of many of these tests is that one looks out for poisoning effects in the terms of common toxicology. The minimum lethal dose is determined and gross poisoning effects are looked for. What counts, however, and which passes un-

noticed, are the often unnoticed dynamic and systemic changes which cannot be easily discovered. In these changes, we see greater dangers because they are hidden.

No on would any longer judge X-ray or gamma radiation damages only on the basis of the first acute burns. Genetic changes may be caused even when gross damages are not seen, that is, as a result of minute repeated "harmless" doses.

The logic in these matters can be compared with somebody playing a game of pool and expecting success when the colliding balls are split or shattered, while the intricacies of the game consist in the deflection and reactions of even minutest "touches."

It would appear from these tests (and much medical and public health opinion is based upon these findings) that DDT is indeed harmless. That this is not the case, the other part of the population feels, and they demand their daily food free of chlorinated hydrocarbons. That their demand is not unjustified is substantiated by some medical reports (38) pointing to the fact that practically no food today is free of DDT; that it inhibits the enzyme reactions necessary for cell oxidation as well as the cytochrome C oxidase.

Velbinger reports that 1000 mg were relatively harmless but caused some neurological symptoms. An oily solution of the same concentration produced marked hyperesthesia in the oral region. A dose of 750 mg affected balance and locomotion. Leucocytosis and both primary and secondary anemia were produced. The question of how fat stored DDT behaves in increased metabolism, with exercise, with a thyroid disease, has not been investigated. A fat storage of 7 ppm sounds like a little. But suppose somebody carried 20 kg fat in his body. This already amounts to 140 mg. The reported high storage of 400 ppm in this case amounts to 800 mg. In one case, this might not cause trouble; with sudden metabolic upsets, the problem might be entirely different. As a matter of principle, foreign substances, even if apparently and temporarily inert, just do not belong in the human body and must be considered potential dangers. Even if most of the DDT in the daily diet is excreted again, special demands on the metabolism for said removal are made. (38b)

"The long consequence of this reaction on the health of the body is still an unknown factor" (Martin). A relationship between certain hepatitis cases and DDT in food was suspected in

a New York hospital. These parts of the population are not satisfied with the seemingly consoling reports quoted above, for they do not contain information on the changes of enzyme reactions and systems in living beings, on the concomitant reactions if other functions of the body are in disorder, on allergies and therefore increased susceptibility. Just because DDT reactions on the subtoxic level can be very inconspicuous and deceiving, being similar to nervous or other disorders, the establishment of minimum tolerances, whether they be low or too high, is an uncertain procedure. DDT in milk is considered to be a contaminant. (Tolerances of 7 ppm in fat of meat cattle, hog, sheep, have been established and already lowered. Pesticide residues were found in 62% of milk supplies 1955-56.) (40) This in itself proves that our lawmakers wish the protection of the population and do not feel at all happy about the situation which has grown out of control. "Safety is the basic consideration," says R. I. White, Chief Registration Section, Livestock Brand, Production and Marketing Administration (41).

Alfalfa was sprayed with DDT at 0.25 lbs./acre level. The DDT residue on the fed hay was 7-8 ppm but butter made from the milk of cows feeding on this hay contained 65 ppm DDT. (42) The question is raised — are we really protected against these accumulating effects even when the original application was below the minimum permissible level?

In rabbits, DDT in corn oil produced a rise in blood sugar. (43) At least one case of a human diabetic is known to this writer whose blood and urine sugar was raised when exposed to an aerosol spray of DDT the equivalent of 10-20 units of insulin.

Weighty arguments are voiced by Prof. Fritz Eichholtz, M.D., Pharmacologist of the Univ. of Heidelberg (44): "The release of DDT from (fat) deposits into the blood can represent a risk, as, f.i., the sudden metabolism of DDT loaded fat storage as a response to states of hunger (p. 45). "Deposits in kidney and liver, as experience has shown, always cause a health hazard because of demonstrable tissue changes."

Eichholtz points to effects upon changes of enzymatic functions. It should be looked upon with suspicion that these have not been studied with regard to DDT. The fact of fast excretion, which is otherwise quoted as a symptom of harmlessness, is not a valid argument, for it has been shown that toxic

changes may occur in spite of it, as was shown with other substances. Three cases are reported where sudden loss of weight caused release of DDT with lethal result. The question was raised whether delayed damages show up, as is the case with X-rays, often years after application. Who knows? Who has studied these problems? The public demands safety. DDT, according to Eichholtz, inhibits carbonic anhydrase, an enzyme in the blood, even in concentrations of 0.4 ppm. The consequences of such changes are not even investigated, nor can they be envisaged.

DDT accumulates in lipoids of testicles, suprarenal glands, the thyroid gland. Male animals showed testicle atrophy. Female animals stored more DDT than males. In animals, DDT showed a mild oestrogenic effect. All these symptoms do not fall into the category of gross toxic pathology as was expected or looked for by the investigators of the penitentiary test. It has recently been discovered that the resistance which builds up in insects is due to enzyme reactions. It is quite possible that effects to the contrary also might occur, that is, enzyme inhibiting effects. This might change the course of a healthy biological function entirely. Who knows? Who has investigated? The answer to all these questions should be given before we speak of harmlessness, inasmuch as the most minute quantities of toxic insecticides can damage the course of these reactions and the danger can remain unnoticed for a long time before a breakdown occurs. The hidden dangers are the ones with which we, as biologists, are concerned, not the obvious gross phenomena.

Prof. W. Schuphan (45) reports that the protein, sugar, acid content of vegetables was noticeably changed when vegetables were sprayed with DDT. Sugar increased, protein nitrogen in percent of total nitrogen decreased, ascorbic acid decreased noticeably. Test animals were fed with vegetables from which the outward adhering DDT was completely removed and only the inward absorbed DDT remained in the feed. The first year showed little reaction with the exception of lower weight curves of the male animals. After the second year, autopsies revealed changes of liver and spleen. The livers were considerably enlarged, the spleens showed atrophy. The life span of these test animals might be compared with a life span of 7-14 years. No autopsies of human livers and spleens after 14 years of continued ingestion of DDT could be performed as yet.

Since genetic changes in the insect realm (by way of resistance) can be observed, (changes which last even after removal of DDT for 18 years), are we sure that on the other side unfavorable genetic changes or damages might not occur, inasmuch as testicles store DDT and enzyme systems are changed? Why do damaging insects build up faster resistance than so-called harmless insects or natural predatory enemies of the bad bug? De we really understand the laws of balances in nature, in long range observations? As long as all these questions are not answered, it appears to this writer that any talk of harmlessness is premature. Proof of harmlessness should be given in every regard; until then, wise restraint seems to be a better policy.

The AMA made a statement to the House Interstate and Foreign Commerce Committee that "a bill dealing with the marketing of foods that might contain residual poisons from pesticides does not have enough safeguards for the public..... according to our interpretation.....there is no provision for prohibiting the marketing and general use of foods containing a pesticide before the determination of a safe tolerance limit of the pesticide in such foods has been made.....It would be disastrous if the entire population of this country served, in effect, as experimental subjects while the safety of food..... was determined." (52)

Last but not least, the reader gets worried when he studies a report on the effect of DDT on synergistic actions of carbon dioxide within the central nervous system. Experiments on cats, an animal which is especially susceptible (more so than the dog), have shown that electrocardiograms and encephalographs show significant reactions and that the effect of DDT was enhanced by the inhalation of air, the carbon dioxide content of which was increased. "The spontaneous rhythm of the cerebral cortex, as well as that of the cerebellum, was significantly modified by the ingestion of DDT." Synergistic effects, that is, the effect of almost anything which is apt to produce increased reactions, have not been investigated at all so far. Nobody knows, in fact, to what synergistic effects he may be exposed. The report quoted mentions that oral ingestion of DDT causes gross symptoms of cerebellar involvement, as demonstrated with electro-encephalographic recordings. It speaks of a "potentiating effect of carbon dioxide with DDT." (58) Some may object that tests with cats do not necessarily reflect

on human beings, even though cats belong to the most resistant and sturdy test animals.

In the history of toxicological effects, a certain pattern of procedure has already been set, that is, a case of precedence exists, when fits in dogs were reported when using agene (nitrogen trichloride) treated flour as dog food. This substance was generally used for the bleaching of flour. When these results were observed, the use of bleaching agents, such as agene, for the processing of grain flour was forbidden at once and manufacturers voluntarily ceased continuing their application. Why not apply a similar practice to insecticides, the health value of which is disputable? So far, only one manufacturer has set an example.

Entomologists, biologists, nature loving and health minded people may understand and study the underlying problem of biological balance which, if fully appreciated, promises an outlook of biological control without toxic sprays. "Chemical companies frequently spend one and one-half million dollars to get a new spray material on the market" says Dr. Walter C. Dutton of the Dow Chemical Co. "It may cost $100,000 just to establish proper residue information for the new chemical." (Am. Fruit Grower, May 1956, p. 16)

One philosophy, the direct outflow of dialectic materialism, sees in the creation of an artificial realm as a result of human intelligence, applied technology, production methods and economy, the progress of civilization. This creation born from human intellect is superimposed on nature. The other philosophy still looks upon nature as the greatest teacher, for in it, in growth, in its wisdom, we see the finger of a higher intelligence, the wisdom of the Creator.

We human beings can strive — at our best — to comprehend only, rather than to imitate or to improve on higher wisdom which, after all, is the foundation to which we owe our existence. If the wisdom and biological balance of nature are violated, for instance, by agricultural production methods geared to the so-called most economic mass production, laws of growth of said biological balance are upset and nature goes her way to teach a lesson.

The increase of pests is faster than the increase of crop yields, for the methods used in agricultural production to increase crops have disturbed the natural balance. We have harvested only what we have sown, in a wider sense. We have

introduced one-sided fertilization methods — monoculture — in order to produce more. This attitude has created the increase of pests. To think now that by "killing" the pests we will remove the causes, is our error. The disturbed balance is only more disturbed and the vicious cycle continues. No problem in human or natural life, in history as well as in the life of the individual, whether physiological or psychological, or a problem between nations, has ever been solved by killing.

However, growth, development, have survived because of the inherent wisdom of a higher order. The study and acceptance of the principles of balance, of life and its functions, is the first step. From these might derive steps of biological control, just by employing nature. So far, the insect has shown more intelligence and has outwitted man. Nature has kept the balance between the destructive and the constructive. We need a long range outlook, not short-sighted temporary solutions.

An economy which does not take this outlook might be profitable for a while, but the whole of the future, of health, of welfare, yes, even of peace, will suffer in the long run. The philosophy of *life*, eventually, will survive. Of this we are convinced. But the price we pay for this conviction may be hard, bitter, and a long path of learning by trial and error is still ahead of us. To change our mind and to begin with the appreciation of the wisdom of nature would seem to lead more quickly to a lasting result. The attitude of man towards this task will decide. This is the attitude of developing moral responsibility towards the future.

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